Permian phytogeography of China

Wang Jun & Shen Guanglong


Based on the characteristics, developing history and geotectonic position of different floral localities, the Permian flora of China may be divided into 13 phytoprovinces which belong to five phytoareas of four phytorealms, respectively.

**Key-words**—Phytogeography, Permian flora, China.

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**THE palaeobotanical data documented up till now indicate that the Permian floral distribution in China was very widespread and China is the only country in the world, where four Late Palaeozoic floras, namely, the Euramerican, Cathaysian, Angaran and Gondwanan floras had developed. Several workers (Li *et al.*, 1979, 1981, 1992; Hsu, 1973, 1976, Hsu *et al.*, 1990; Zhang *et al.*, 1985; Zhang, 1989; Huang, 1977, 1993; Hu, 1985; Wu, 1993; Sun *et al.*, 1991; Sun, 1989; Shen *et al.*, 1989, 1990, 1992; Asama, 1976; Halle, 1935, 1937; Kimura, 1987; Kon’no, 1968) described the outline of the Permian phytoprovince of China in different ways, but no comprehensive synthesis has been prepared. Based on both the available material and principles of phytogeography, a primary framework concerning the Permian phytogeography of China for the future theoretical studies is compiled.

**DIVISION AND CHARACTER OF PERMIAN PHYTOPROVINCE IN CHINA**

On the basis of various features of individual floras, with regard to the particular developmental conditions of the palaeovegetation during different stages of the Permian, as well as the geotectonic position of floral localities, the Permian floral distribution of China may be divided into the following 4 phytorealms, 5 phytoareas and 13 phytoprovinces (Wang *et al.*, 1996; Text-figure 1; Table 1).

1. **The Cathaysian Phytorealm**

1.1. The North China Phytoarea

1.1.1. The Qilian-Alashan (Alxa) Phytoprovince

1.1.2. The Daqingshan-Tumen Phytoprovince

1.1.3. The Shaanxi-Shanxi-W. Shandong Phytoprovince

1.1.4. The W. Henan-N. Anhui Phytoarea

1.2. The South China Phytoarea

1.2.1. The Jiangnan Phytoprovince

1.2.2. The Yangtze Phytoprovince

1.2.3. The N. Tibet-S. Qinghai Phytoprovince

2. **The Angarian Phytorealm**

2.1. The Peri-Angarian Phytoarea

2.1.1. The Junggar Phytoprovince

2.1.2. The Beishan Phytoprovince
2.1.3. The Hinggan Phytoprovince

3. The Euramerican Phytorealm

3.1. The Central Asian Phytoarea

3.1.1. The Tarim Phytoprovince

4. The Gondwanan Phytorealm

4.1. The N.E. Gondwanan Phytoarea

4.1.1. The Gangdise Phytoprovince

4.1.2. The Himalayan Phytoprovince

The main characteristics of each phytounit may be briefly described as follows:

1. The Cathaysian Phytorealm—It covers the largest part of China proper. The main features of this phytorealm are: (i) at the lowermost Permian it was characterized by such oriental-type lepidophytes as Lepidodendron posthumii, L. oculus-fei, L. szetanum and Cathaysiodendron nanpiaoense and the endemic genus Tingia, with certain species of the Sphenopsida and Filicopsida (particularly Pecopteris) which are very abundant during the Stephanian stage in the Euramerican Phytorealm; (ii) at the middle stage of the Early Permian, a number of endemic species such as Emploctopteris, Emploctopteridium and Lobatannularia started to develop, but the typical gigantopterids including Gigantonomocla and Cathaysiopteris were far from common; (iii) from the late stage of the Early Permian to the early stage of Late Permian, along with the decline of the "Oriental lepidophytes", gigantopterids and Lobatannularia rapidly developed to dominate, and also certain endemic elements including Fascipteris, Otofolium and Yuania appeared, then spread rapidly one after another; (iv) at the late stage of the Late Permian, gigantopterids were limited to the Yangtze block and N. Tibet-S. Qinghai region. Moreover, some western European Zechstein xerophytes have been found recently in the Uppermost Permian of N. China.
Table 1—Showing distribution of Permian Phytoprovinces in China and their geotectonic position

<table>
<thead>
<tr>
<th>Phytorealm</th>
<th>Phytoarea</th>
<th>Geographical area</th>
<th>Geotectonic unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. 1.1</td>
<td>North Xinjiang (southward to the Tianshan Mt.)</td>
<td>Beishan area in Gansu and a small part of western Inner Mongolia</td>
<td>Tianshan-Hinggan Hercynian Fold Belt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Da Hinggan Range, Xiao Hinggan Range and Northeast China Plain</td>
<td></td>
</tr>
<tr>
<td>I. 1.1</td>
<td>Westward to the Altun Mt., eastward to the Ordos Basin, northward to Beishan area southward to the Qaidam Basin(?)</td>
<td>The Yinshan Mt., Daqingshan Mt. the hinterland of Yanshan and west Liaoning</td>
<td>Alxa Block, Hexi Corridor border Fold Belt, Qilian Caledonian Fold Belt</td>
</tr>
<tr>
<td>I. 1.1</td>
<td></td>
<td>The Ordos Basin, Shanxi Prov., West Shandong and Hebei Prov.</td>
<td>The North China Block</td>
</tr>
<tr>
<td>I. 1.1</td>
<td>West Henan and North Anhui</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. 2.1</td>
<td>Fujian, Zhejiang, Jiangxi, Guandong, Hunan, Guangxi and a part of Jiangsu and Anhui</td>
<td>Hubei, Sichuan, Guizhou and East Yunnan</td>
<td>The South China Block and Jiangnan Block</td>
</tr>
<tr>
<td>I. 2.2</td>
<td></td>
<td>Middle-North Tibet and South Qinghai</td>
<td>The Yangtze Block</td>
</tr>
<tr>
<td>I. 1.1</td>
<td>South Xinjiang (Tarim Basin)</td>
<td></td>
<td>The Tarim Block</td>
</tr>
<tr>
<td>N. 1.1</td>
<td>Himalaya Mt.</td>
<td></td>
<td>Himalayan Block</td>
</tr>
<tr>
<td>N. 1.1</td>
<td></td>
<td>Gangdise Mt.</td>
<td>Gangdise Block</td>
</tr>
</tbody>
</table>

...coexisting with a few Cathaysian species. In addition, what is worthy of mention is that in the northern margin of N. China Phytoarea there were a few mixed floras of both Cathaysian and Angarian, which shows the migrating and expanding process between the two different palaeofloras.

Li et al. (1979) divided the Cathaysian Province into two subprovince: the North China and South China subprovinces. Recently, Du and Mei (1994) divided it into four independent units, namely the N. China subprovince, S. China subprovince, Qilian-Tarim subprovince and Yu Huai subprovince. With respect to this recent data, the present authors divide the Cathaysian Province into two phytoareas and subdivide them into seven phytoprovinces, about which brief characteristic descriptions are presented as follows:

1.1: The N. China Phytoarea included four phytoprovinces

1.1.1: The Qilian-Alashan (Alxa) Phytoprovince—The floral aspect was closely similar to that of the Shaanxi-Shanxi-W. Shandong Phytoprovince excepting for the poor development of gigantopterids until the early stage of the Late Permian. During the Late Permian more species with a Subangaran aspect existed here to form the distinct Subangaran-Cathaysian mixed flora.
1.1.2: The Daqingshan-Tumen Phytoprovince—With its general plant aspect consistent with that of the N. China Phytoarea, this phytoprovince was characterized by relatively more diversified *Emplectopteris*, several species of which were endemic, and invasion by a few endemic plants of the subangarian during the Late Permian.

1.1.3: The Shaanxi-Shanxi- W. Shandong Phytoprovince—It was the typical example of the N. China Phytoarea, despite the appearance of a few Zechstein and Angarian plants in the uppermost Permian.

1.1.4: The W. Henan-N. Anhui Phytoprovince—It holds a strong relationship to both, the N. China and the South China Phytoareas, where gigantopterids were developed relatively well; a few species of which were endemic.

1.2: The South China Phytoarea includes three Phytoprovinces

1.2.1: The Jiangnan Phytoprovince—This phytoprovince appeared in the middle stage of Early Permian and flourished from the late stage of the Early Permian to the early stage of the Late Permian. The flora of this region was typical of the Gigantopteris flora dominated by gigantopterids.

1.2.2: The Yangtze Phytoprovince—The floral aspect of this phytoprovince was closely similar to that of Jiangnan with the strong prevalence of gigantopterids. It reached its greatest development in the Late Permian and in local cases persisted into the lowest of the Upper Triassic.

1.2.3: The N. Tibet-S. Qinghai Phytoprovince—Apart from a few endemic species, the floral aspect closely resembles that of the Yangtze Phytoprovince. What was significant is that the *Gigantonoclea guizhouensis*-Selaginellites tibeticus* assemblage might be regard as the latest assemblage of the Cathaysian flora, representing probably the latest phase of the last Permian flora in the world (Li et al., 1981).

2: The Peri-Angaran Phytoarea—Angaranopteridium, Angarites and *Noeggerathiopsis* have always been reported in the Junggar-Hinggan region, Northwest and Northeast China occurring since Carboniferous, which indicates a strong Angaran floral aspect. Furthermore, upon entering into the Permian time, the appearance of many subangarian genera, namely *Paracalamites*, *Koretophyllites*, *Callipteris*, *Zamipteris*, *Purssongia*, *Comia*, *Iniopteris*, *Lepeophyllum*, *Sylvia*, *Nephropsis* and *Crassinervis* together with the disappearance of some Euramerican genera that had been common from the Late Carboniferous to Early Permian, and the lack of typical Cathaysian genera definitely indicates that the region belongs to the Angarian phytorealm. According to the components of individual floras, the phytoarea can be divided into three phytoprovinces including the Junggar Phytoprovince, the Beishan Phytoprovince and the Hinggan Phytoprovince. In Beishan region, the flora most strongly developed in the Late Permian, dominated by subangarian elements, with certain Cathaysian members intermingled, with none endemic, due to which it showed similarity to that of the southwestercly adjacent Qilian-Alashan Phytoprovince; in Hinggan Phytoprovince, the flora was characterized by abundant endemic species, with a few species of *Lobatannularia* scattered along the southern boundary at the late stage of the Late Permian.

3: The Central Asian Phytoarea—During the middle stage of the Early Permian, the flora was dominated by Euramerican species, of which *Autunia* was dominant, none of the typical Cathaysian or Angaran species were developed, and overall aspect of the plant assemblage was consistent simultaneously with that of the Central Asian phytoprovince, so that the Tarim Phytoprovince can be distinguished. Such a phase was maintained through the late stage of the Early Permian, while *Paracalamites* and *Noeggerathiopsis* first appeared till the late Early Permian, then along with the closing of the Tianshan Trough, some subangaran elements such as *Iniopteris*, *Comia*, *Zamipteris* and *Callipteris* migrated into and replaced the previous Euramerican ones, transforming the former Euramerican Phytoarea into the Peri-Angarian Phytoarea.

4: The N.E. Gondwan Phytoarea—It refers to the Qubu flora in the middle-late stage of Early Permian and the Xiagang Jiang flora in the latest stage of the Early Permian. The Qubu flora, which was distinguished by the *Glossopteris communis-Austroanunnularia qubensis* Assemblage, bears a striking resemblance with the coeval Kashmir flora. Some palaeobotanists refered it as a Gondwanan-Cathaysian mixed flora because its representative
Table 2

<table>
<thead>
<tr>
<th>Age</th>
<th>Early Permian ($P_1$)</th>
<th>Late Permian ($P_3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytounit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.1</td>
<td>Unnamed Assemblage</td>
<td>&quot;Callipteris&quot; zeilleri-Comia detata Assemblage</td>
</tr>
<tr>
<td>I.3</td>
<td>(Marine deposits)</td>
<td>&quot;C.&quot; ad-Ins. 1 Assemblage</td>
</tr>
<tr>
<td>I.4</td>
<td>No. s-Ne. o Assemblage</td>
<td>Co. y-Lob. h Assemblage</td>
</tr>
<tr>
<td>I.5</td>
<td>Zamiopteris lanceolata-Neog. deraquinii Assemblage</td>
<td></td>
</tr>
<tr>
<td>I.6</td>
<td>Empleopteris triangularis-Empleopteris triangularis alatum</td>
<td>Al. n-Lob. s Assemblage</td>
</tr>
<tr>
<td>I.7</td>
<td>Lepidodendron -posthumii Assemblage</td>
<td>Y. s-Cl. o Assemblage</td>
</tr>
<tr>
<td>I.8</td>
<td>Neuropteris pseudovata</td>
<td>In. s-Lob. 1 Assemblage</td>
</tr>
<tr>
<td>I.9</td>
<td>Empleopteris pseudovata-Empleopteris pseudovata</td>
<td></td>
</tr>
<tr>
<td>I.10</td>
<td>Lepidodendron pseudovata</td>
<td></td>
</tr>
<tr>
<td>I.11</td>
<td>Assemblage</td>
<td></td>
</tr>
<tr>
<td>I.12</td>
<td>Empleopteris pseudovata-Empleopteris pseudovata</td>
<td></td>
</tr>
<tr>
<td>I.13</td>
<td>(Marine deposits)</td>
<td></td>
</tr>
<tr>
<td>I.14</td>
<td>Gl. d.-R. c Assemblage</td>
<td>Ga. g.-Sel. Assemblage</td>
</tr>
<tr>
<td>I.15</td>
<td>Aust.-Cl. k Assemblage</td>
<td></td>
</tr>
<tr>
<td>I.16</td>
<td>Noeg.-Psyg. Assemblage</td>
<td>&quot;Ca.&quot; zeilleri-Comia kulganensis Assemblage</td>
</tr>
<tr>
<td>I.17</td>
<td>Noeg.-Pl. Assemblage</td>
<td></td>
</tr>
<tr>
<td>I.18</td>
<td>Cl. c-Aust. q. Assemblage</td>
<td>(Marine deposits)</td>
</tr>
</tbody>
</table>

species Austroannularia qubuenensis is strongly similar to Lobatannularia, however, it lacks the typical Cathaysian genus Gigantonoclea which suggests a closer relationship to the Indian Gondwana flora. The Xiagang Jiang flora also showed some relation to that of the Cathaysian Phytorealm by the presence of Pecopteris arcurata and Plagiozamites oblongifolius. Overall, based on the available data, it is reasonable to identify the relevant area as two independent phytounits in the N.E. Gondwana Phytoprovince, namely the Himalayan and Gangdise phytoprovinces respectively.

Because of the limited space, it is impossible to analyse the provincial characters in greater details. The main characters are summarized in Table 2.

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